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PROBLEMS OF GLIDER MODELS

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PROBLEM OF GLIDER MODELS.*

By Lippisch Espenlaub.

Any one endeavoring to solve the problem of soaring flight is confronted not only by structural difficulties, but also by the often far more difficult aerodynamic problem of flight properties and efficiency, which can only be determined by experimenting with the finished glider.

In designing, we confine our attention mostly to similar, already tested types and compute the angle of attack and the horizontal and vertical speeds from the polar diagram of the wing section. Still, with all data, there is always much that is indefinite and we cannot determine directly whether the projected glider might be further improved.

These problems may be partially solved by computation, but the calculations are very complicated and ultimately only the influence of the wing section, the aspect ratio and the head resistance can be computed.

Comprehensive wind-tunnel experiments can only be made by the select few. We will therefore consider open-air experiments with glider models. Experiments with mechanically-driven airplan models constituted the original basis of airplane construction and still boast many adherents.

In many respects, however, such experiments are not adapted to the determination of the aerodynamic properties of airfoils or airfoil systems, since with models, the same as with full-size

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airplanes, the propelling force is always the decisive factor and the efficiency of the airfoil system is not fully brought out. As the relations vary on full-size airplanes between engine-driven flight and soaring flight, so they do likewise on models.

In soaring or gliding flight, where alone the aerodynamic and aerostatic construction is decisive, we obtain, through a series of systematic experiments, a clear conception of the properties of certain types.

Before going deeper into the method of experimentation, we wil say something concerning the making of the models, strength being the first condition. We learn nothing from a model which breaks after a few flights, even though it has been made at the expense of much painstaking labor. In the first experiments, we confine ourselves, therefore, to the simplest forms, e.g., airfoils made from thin cardboard shaped over thin strips of wood (Fig. 1C). Simple cardboard answers for smaller models. Thin plywood gives a very firm surface, and can be variously curved.

Let us take, as the starting point, for example, a monoplane, as shown in Fig. 1.

Fig. 1A is a plan view of model;

Fig. 1B is a cross-section through middle of wing, showing method of assembly;

Fig. 1C is any section of the wing.

The fuselage is a simple rod, with a sliding weight on a wire for adjusting the center of gravity. The airfoil is so attached to this rod, that the angle of attack is adjustable, as also the distance between the wing and the tail plane.

Since we wish to test variously shaped surfaces, we will choose an easily separable combination, so that we can set the wings in turn on the fuselage and thus test the different wings under the same weather conditions. The movable weight must be at least as heavy as the model itself. The lighter the model in comparison with this weight, the steadier it will fly.

As the place for the experiments, we will choose a hill, from which the models can fly a long distance. The wind must not be too strong, 2 to 5 m/sec being the most favorable.

In adjusting the center of gravity, care must be taken to avoid nose heaviness in too steep gliding. Models which then go into a dive indicate too short a distance between fuselage and wing

Tail heaviness is recognized by a settling at a large angle of attack and, in a lesser degree, by a slight rolling and poor longitudinal stability, both due to an excessive angle of attack. The employment of a vertical keel is, in most cases, of little use in maintaining the direction of flight. Symmetrical warping, i.e., diminishing the angle of attack toward the outer ends of the wing, works better. If the model turns to the right or the left, we ben the opposite trailing edge slightly up.

The following are the most important systematic series of experiments.

1. Effect of reducing distance between wing and tail plane.- Wing adjustment. The change in the angle of glide and the necessary displacement of the center of gravity is noted. Its most favorable location, so that the tail plane will not be stressed and the cente

of gravity will coincide with the center of pressure for the best angle of glide, lies at 0.3 to 0.4 of the chord from the leading edge.

2. Effect of symmetrical warping of wing.- The angle of attack is most readily reduced by warping the wing. Accurate forms can be obtained by shaping over patterns. We may try wings, both with angle of attack diminishing outward and also increasing outward. The experiments will show, in general, that reducing the angle of attack increases the flight stability. Special aerodynamic advantages are not to be expected.

3. Effect of distance between wing and tail plane.- For this investigation, the model is so constructed that the tail plane can be moved. The experiment is begun with the longest fuselage to be tested (about 1/2 the span) and the distance is then reduced until instability occurs, the fuselage of course being shortened at the same time. It will be found that short-fuselaged models exhibit better soaring characteristics. This fact is important, since too great longitudinal stability renders the motions slow and unable to take advantage of gusts. The weight of the fuselage plays an important role. We are investigating this matter thoroughly.

4. Effect of dihedral and sweepback.- The effect of the dihedral is generally known. It is noticed that such models are liable to roll. A negative dihedral with upturned wing tips and sweepback, gives a good soaring tailless shape, which can often be noted in birds (Fig. 3). A sweepback increases both longitudinal and lateral stability.

5. Wing shapes.- In Fig. 3, several common shapes are given, all of which have an aspect ratio of 1 : 10 (span of model 1000 mm) The differences in their flight properties are not great. A moderate tapering of the wing, as in Fig. 3, D, E, and F, gives results similar to those mentioned in paragraph 2. The advantages of such shapes lie more in the matter of construction, since the forces of torsion can be more readily taken up. Here should be mentioned also the shapes with automatic stability. All the wings are designed on the principle of employing the more or less swept-back tips as stabilizers, which is accomplished by means of a negative angle of attack. The shapes employed are those of the Zanonia wings (Wels-Etrich), Dunne wings and Weltensegler wings. There were also used as models, a whole series of other shapes, which represented sections of the surface of geometrical bodies. Soaring-flight models, built on this principle, often exhibit very good flight characteristics and are quickly and easily made. Their conversion into full-size gliders is accompanied however by structural difficulties, due to the fact that the wing tips, designed to serve as stabilizers, exert a strong torsional stress on the wing spars. This circumstance demands a considerably higher weight of the wing to offset the absence of the fuselage.

6. Effect of aspect ratio.- This matter is generally well understood. A good aspect ratio is essential for a good angle of glide and a low descending speed. The models are made with a certain constant dimension (e.g. span or surface area). The experimental ratio should be varied as much as possible (at least up to

1 : 20). It will soon be apparent that the soaring ability of the model is greatly improved by a good aspect ratio. A good aspect ratio not only makes itself felt in the aerodynamic characteristics (angle of glide, etc.), but also contributes much to flight stability. In the treatment of this question, reference is often made to soaring birds, especially sea birds, such as the mew, albatros and frigate bird. Our native land-birds, aside from the swallows, have no good aspect ratio at all. From this fact, we may perhaps draw the following inference. The mean strength of the wind determines the wing load and the latter determines the aspect ratio. Unfortunately, we find in the literature on this subject only very inaccurate and discrepant data.

7. Effect of wing section.- This is closely related to the problem of the aspect ratio. It is not possible, however, to perform perfect experiments in this connection with soaring-flight models. There are now, however, sufficient data. Nevertheless, we must not neglect to obtain information on the effect of wing curvature and thickness by experiment. The low speeds of most models necessitate small-cambered, thin wing sections. Thick wings can be used only on large, heavily-loaded models. Perhaps, with such models, we shall be able to obtain information on the much-discussed Widderhorn vortex. Interesting results are obtained with wing sections whose curvature increases with the angle of attack. This result is best obtained by dividing the wing section into two or three parts connected by hinges. The adjustment is effected by means of special surfaces which increase the curvature with increase

of pressure. Such a wing is similar to a flexible surface, but has the structural advantage of being simpler, since all the members are rigid in themselves. That a flexible wing works better than a rigid one can be easily demonstrated by experiments with models. The problem of adjustability may, however, be solved in other ways and such solutions are doubtless preferable when made with structural members which are rigid in themselves. In conclusion, I wish to emphasize the fact that, in all experiments with models, the ultimate application to full-size gliders should be kept in mind. The best-flying model is of but little value, if it cannot be reproduced as a full-size glider.

Translated by the National Advisory Committee for Aeronautics.

a – 100 mm.		g – 80 mm.		p – 127 mm.	
b – 600 "		h – 120 "		q – 119 "	
c – 50 "		j – 76 "		r – 340 "	
d – 150 "		k – 103 "		s – 142 "	
e – Sliding weight		m – 116 "		t – 952 "	Rad.
f – 1000 mm.		n – 125 "		u – Adjusting screw	

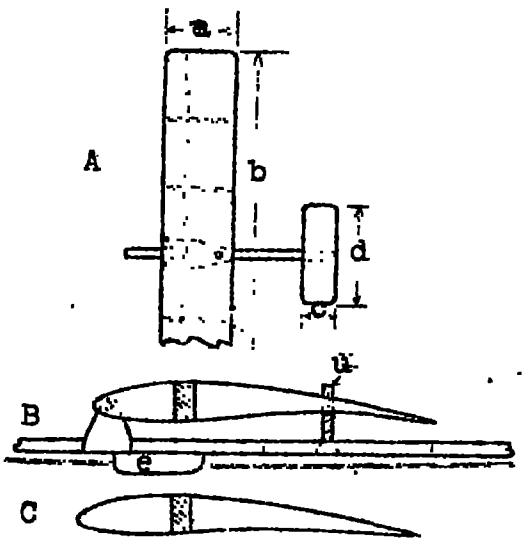

Fig.1

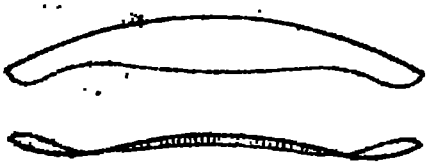

Fig.2

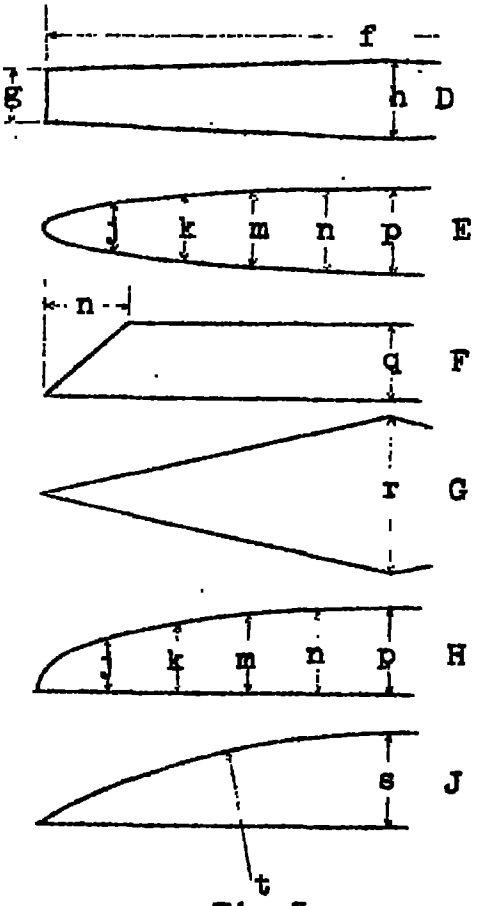

Fig.3